EQL MEMORANDUM NO. 6

TRENDS OF ENERGY USE IN CALIFORNIA AND THE SOUTH COAST AIR BASIN

by

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ABOUT THE AUTHOR

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TRENDS OF ENERGY USE IN CALIFORNIA

AND THE SOUTH COAST AIR BASIN

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0. Introduction and Comparison with E. J. List's Report

This report provides a time history of the major sources of energy described for 1969 in List's report, "Energy Use in California" [18]. As the data are compiled differently in these two reports, a comparison and interpretation is shown for 1969. (See Table 0-1). The column labelled 1969 contains the data from the present work, and column labelled List contains the data from Table 2-2 of his report.

The major difference is that his data are only for fuel used to provide energy within the state boundaries, while this report includes consumption for uses other than energy (e.g., LPG for chemical feedstock) and fuel used outside the state that was sold in the state (e.g., oil for ocean vessels). Natural gas delivered, gasoline, and LPG burned show good agreement. In the Fuel Oil category, List excludes about 32 million barrels of residual oil used by vessels and the military out of state, and about 11 million barrels of distillate (or diesel) oil used by railroads and the military out of state. Revisions by the Bureau of Mines of the 1969 fuel oil figures after List's report was completed account for the remainder of the difference.

California's total electricity production agrees very well. List's electricity use data include transmission and other losses with electricity sales. Assuming transmission losses of 7% (an estimate based on national data), there is good agreement between the reports. The large difference in production of electricity (gas and oil excluded) is because List's report is in error. Although his calculations for each air basin are correct, some of the energy is counted twice in his statewide total for this category.

For the South Coast air basin, natural gas use agrees well between the two reports, while both gasoline use and electricity use are about 7% greater in the present work. In both reports, the data for the latter two categories were computed by finding, for each county that lies in more than one air basin, the proportion of population in the South Coast air basin, and apportioning that fraction of the county's total usage to the South Coast. Hence, the disagreement in the resulting data must arise from differences in these estimates. The data for fuel oil use in the South Coast were not available on a continuing basis and are not included in this report. According to List, it is about 7% of the total energy used in the South Coast.

It must be emphasized, however, that differences in the data with List for 1969 should not affect the accuracy of the growth rates given in this work. Sources of information were used that kept data for the entire 20 year scope of this work, so, hopefully, any peculiarities in the compilation of the data are consistent from year to year and growth rates are not affected.

TABLE 0-1

CALIFORNIA

	1969	LIST	
Natural Gas (billion cu. ft.)			
Gross Consumption	2079		
Delivered	1948	1851	
Gasoline (mill. gallons)	8860	8654	
Fuel Oil (thousand bbls.)			
Residual	73,638	39,112	←State use
Distillate	39,602	18,600	←Diesel, state use
LPG (mill. gallons)			
All uses	690		
Burned	387	387	
Electricity (GWH)			
Total Production	120,042		
Utilities Production	118,317	118,700	
Sales	111,392		
Sales + 7% losses	(119,000)	117,973	State Use

SOUTH COAST

Natural Gas (billion cu. ft.)			
Sales	903	910	
Gasoline (mill. gallons)			
Highway use	4330	4050	Use
Electricity (GWH)			
Sales	56,800		
Sales + 7% losses	(60,000)	56,184	Use

1. Summary

Consumption of energy in California increased by an average of 4.2% annually from 1960 to 1970. The source of the increase was an average 2.4% increase in population coupled with an average 1.7% annual increase in per capita usage. It is known from List's report [18] that approximately 90% of the energy used each year is from four sources: natural gas, motor fuels including gasoline and diesel oil, fuel oil, and electricity not produced by gas or oil. The current work provides a growth history of these four sources of energy and an estimated annual total assuming those four provide 90% of the energy used. (See Table 1-1). Natural gas is the source of almost half the energy used in the state. Motor fuels are the source of about 25% of the energy used.

Although the amount of electricity generated by hydroelectric and nuclear power is relatively small, the total amount of energy used to produce electric energy is about 20% of the energy budget. (See Table 1-2). This is because gas and oil powered steam-electric generation have efficiencies of 1/3. It is assumed here that hydroelectric and nuclear power have 100% energy conversion.

California imports 70% of the natural gas it uses each year, (Fig 3-1). The state now produces almost all the electricity it uses, but by 1980 it appears that 15% of the electricity used here

will be generated out of the state (Fig 3-4). The South Coast is even less self-sufficient than the state -- currently about 20% of the electricity used here is imported and this figure is projected to rise to 40% by 1980 (Fig 4-2).

The direct cost of energy to the consumer has decreased as a percent of average income from 10.7% in 1960 to 9.0% in 1970. The real cost of natural gas and gasoline declined in this period, while the real cost of electricity increased slightly (Table 6-1).

TABLE 1-1

HISTORICAL CALIFORNIA ENERGY SOURCES

(Common Units - 10^6 MWH)

	Natural Gas	Motor Fuel	Fuel Oil	Hydro & Nuclear	Estimated Total
1970	665	349	208	41	1385
1965	541	272	186	31	1130
1960	404	209	190	17	910
Average Annual Increase	5.0%	5.1%	0.9%	8.8%	4.2%

TABLE 1-2

HISTORICAL ENERGY CONSUMPTION BY FINAL FORM

(Common Units - 10^6 MWH)

	Natural Gas (Excluding Use for Electricity)	Motor Fuel (Gasoline and Diesel)	Fuel Oil (Exc. Use for Electricity	Energy For Production of Electricity
1970	468	352	148	278
1965	386	274	155	214
1960	303	209	148	160
Average Annual Increase	4.3%	5.1%	0%	5.5%

2. Population of California and the South Coast Air Basin

The population table gives the populations of California, the South Coast, and the counties forming the South Coast for each of the years 1960 - 1972 and the Census years from 1920 - 1970. For the counties that do not lie entirely in the South Coast Air Basin, the approximate population (and percentage) in the Basin is given. This approximation is based on the U. S. Census District populations, most of which are either wholly in or out of the Basin. After 1960, the few districts that were split had small populations, so the maximum possible error is about 3000 people in Riverside, San Bernardino, and Santa Barbara, and about 10,000 in L. A. County. Before 1960, the Census districts were larger, so the Basin approximation is somewhat less accurate.

The state of California compiles a county census for the controller each year which varies from the U. S. figures by up to 2% in the U. S. Census years. The U. S. figures are taken as being more accurate, and the state figures in the intervening years have been modified accordingly.

It can be seen from Fig. 2-1 that the growth rates of California and the South Coast have been almost the same since 1930, and that the growth rates of L. A. County and the South Coast were the same until 1960. Since 1960 however, L. A.'s

average growth proceeded at 1.3% annually (ZERO since 1968) while the South Coast gained an average 2.2% per year. L. A.'s share of the Basin population declined from 79% in 1960 to 69% in 1972. Rapidly growing Orange County has risen from 9.2% to 15.7% of the Basin's population from 1960 to 1972. (This county has grown at an average 6.6% per year since 1960, and an average 11.8% a year during the 1950s). Fig. 2-2 shows the growth rates since 1960 of the state, the South Coast, and L. A. and Orange Counties. There is a general, though slight, decrease in growth rates in the last 12 years.

Some sources use a population density for the South Coast obtained by dividing the population by the total area of the air basin (9219 sq. mi.). Much of this area is mountainous, so a more realistic population density is calculated here using only the non-mountainous area in the basin. The average density in the air basin is then 3660 persons/sq. mile. (See Table next page).

COUNTY	AIR BASIN NON-MOUNTAINOUS AREA (SQ. MI.)	1972 POPULATION IN BASIN	DENSITY PERSONS/ SQ. MI.
Los Angeles	1070	6,882,000	6430
Orange	350	1,557,000	4450
Riverside	630	350,000	550
San Bernardino	420	577,000	1390
Santa Barbara	70	170,000	2320
Ventura	180	410,000	2280
South Coast Total	2720	9,946,000	3660

A very crude population projection can be made assuming that population continues to increase until some critical density is achieved. This assumes that the suburbs will eventually become as densely populated as the older parts of the city, and that these older areas have achieved their maximum populations -- this was the general population trend in the New York metropolitan area. Under this assumption, a maximum density of about 6400 persons/sq. mi. would be indicated for the basin area, since the population of L. A. County has stabilized at that level. This assumed upper bound would affect Orange County's growth in 1980 when its population would be nearly 2.3 million people. The population projections in Fig. 2-1 are based solely on this assumption.

TABLE 2-1

Population Data (Adjusted State figures)

Top figure for each year is population in basin, bottom figure is population in county or state

(Thousands)

	South Coast	L.A.	Orange	Riverside	San Bernardino	Santa Barbara	Ventura	California	
1972	9946	6882	1557	350	577	170	410		
		6969	1557	484	694	296	410	20,474	'72
1971	9903	6948	1486	340	571	164	394		
		7033	1486	471	687	285	394	20,239	'71
		98.88%		71.6%	83.1%	57.6%			
'70	9800	6954	1420	329	566	152	378		
		7036.887	1420.248	459.074	681.535	264.324	378.497	19,953.134	'70
'69	9734	6960	1371	321	561	150	371		
		7021	1371	450	670	263	371	19,786	'69
'68	9551	6882	1316	308	544	147	354		
		6961	1316	434	656	257	354	19,474	'68
'67	9410	6827	1262	300	532	145	344		
		6904	1262	426	641	254	344	19,171	'67
'66	9198	6720	1196	294	517	142	329		
		6795	1196	418	623	250	329	18,774	'66
'65	9040	6676	1129	279	510	137	309		
		6749	1129	402	615	243	309	18,410	'65
'64	8798	6568	1049	273	490	134	284		
		6639	1049	380	591	236	284	17,921	'64
'63	8492	6441	956	245	467	128	255		
		6512	956	355	563	226	255	17,423	'63
'62	8139	6260	856	229	443	118	233		
		6329	856	333	535	209	233	16,782	'62
'61	7858	6123	773	216	428	104	214		
		6190	773	316	517	185	214	16,229	'61
		98.9		68.0	82.8	56.0			
'60	7594	5972	704	208	417	94	199		
		6038.771	703.925	306.191	503.591	168.962	199.138	15,717.204	'60
		99.6		70	87	64			
'50	4894	4136	216	119	245	63	115		
		4151.687	216.224	170.046	281.642	98.220	114.647	10,586.223	'50
		99.7		74	89	71			
'40	3251	2778	131	78	144	50	70		
		2785.643	130.760	105.524	161.108	70.555	69.685	6,907.357	'40
		99.8		77	95	72			
'30	2616	2205	119	63	127	47	55		
		2208.492	118.674	81.024	133.900	65.167	54.976	5,677.251	'30
		99.8		75	92	62			
'20	1153	934	61	37	67	25	29		
		936.455	61.375	50.297	73.401	41.097	28.724	3,426.861	'20

Figure 2-1

LONG TERM POPULATION GROWTH

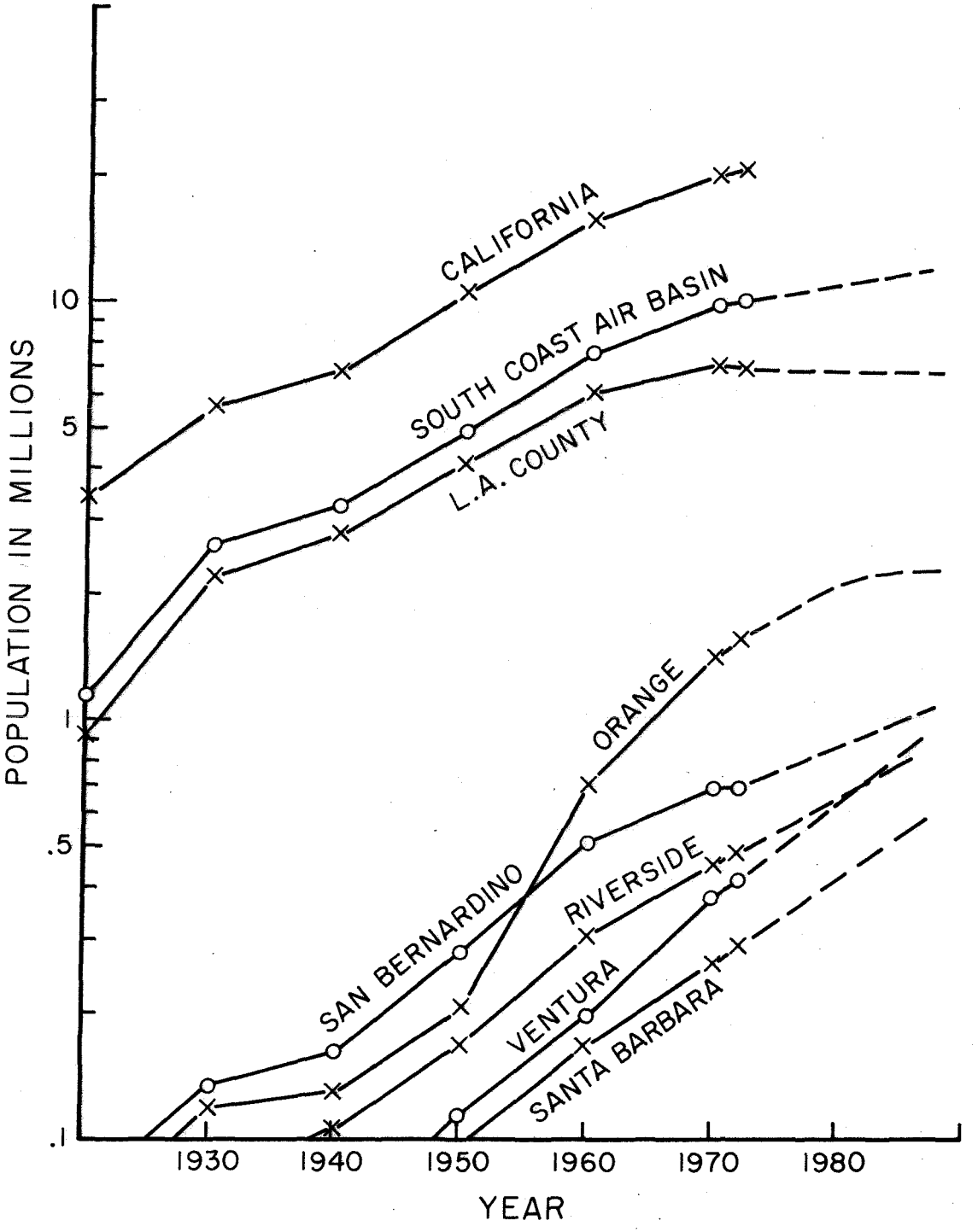
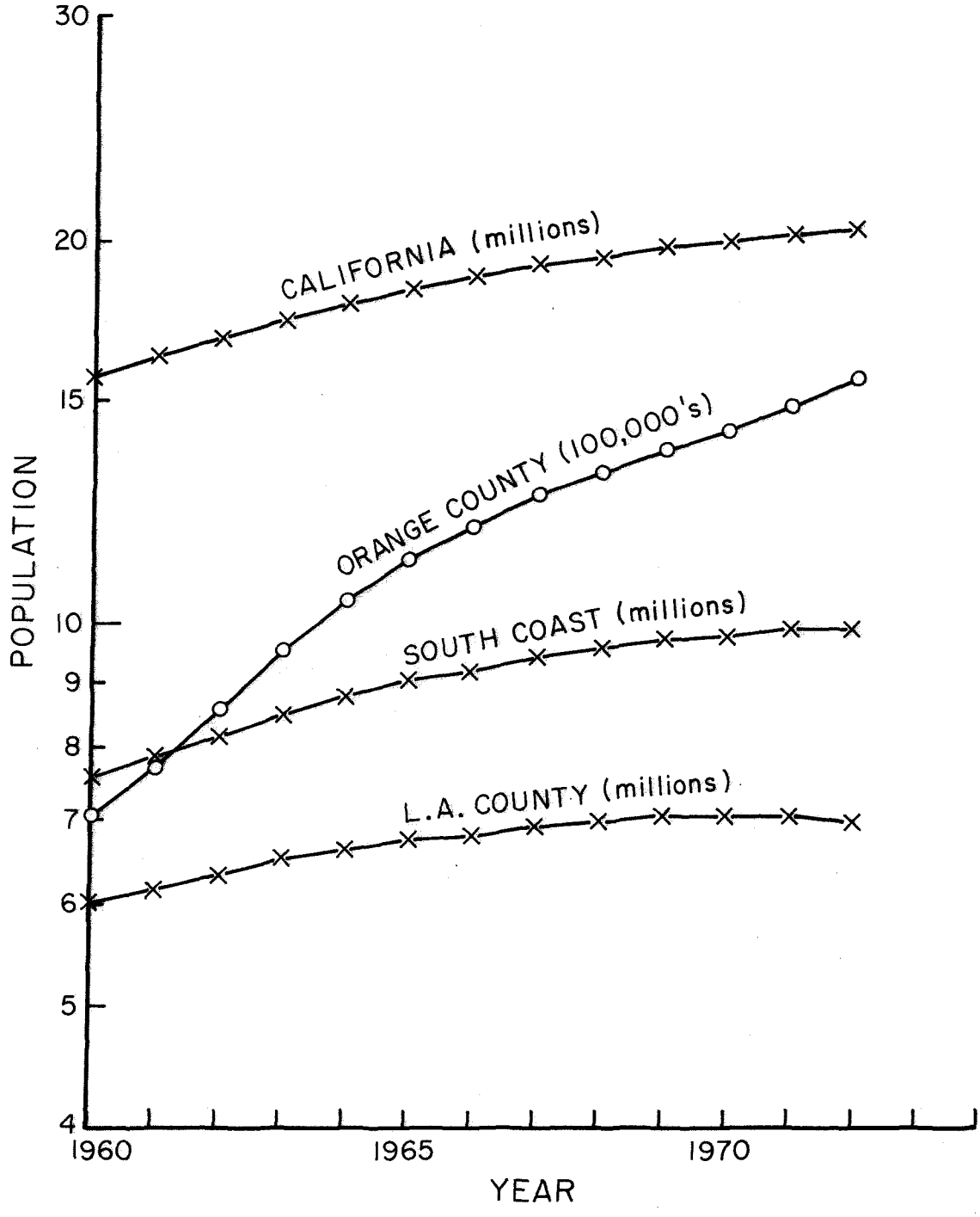


Figure 2-2

RECENT POPULATION GROWTH



3.1 Natural Gas

Natural gas was not imported into California until 1947. Since that time, state production has increased an average of less than 1% annually while state consumption has increased at an average 5.7% annually. The difference has been made up by increased imports (11.8% average increase each year since 1950) which in 1970 provided 72% of the natural gas used. (See Fig. 3-1). Table 3-1 shows the statewide flow of natural gas from producer to consumer. Marketed production is total gas sold and that consumed by producers, including gas loss to natural gas liquids recovery, losses in transmission, quantities added to storage, and increases of gas in pipelines. It does not include gas used for repressuring and quantities vented or flared. Gas Received is the import of gas from interstate movements. The sum of these two minus the transmission loss and the change in underground storage gives Total Consumption.

The difference between Total Consumption and Delivered to Consumers is the amount for field use (pumping, drilling, extraction loss and plant fuel), pipeline fuel, and production of carbon black. Deliveries are then broken down into five categories. Electric utilities is the amount used by power plants and it includes a small quantity of refinery made gas. Industrial use includes all industries except utilities -- the major consumers being refineries, chemical

and allied produce industries, the metals industry, the building materials industry, the glass industry, foods, and paper and allied products. The column headed Other includes sales to public authorities and municipalities.

Fig. 3-2 compares the market share of gas consumption by category. Residential, industrial and utilities each occupy about 30% of the market, while commercial only occupies 10%. Utility consumption has increased by an average of 10.5% annually since 1950. The oscillations in the utilities curve are caused by the availability of more desirable hydroelectric power. Since 1950, residential, commercial, and industrial use increased nearly equally at averages of 5.6%, 5.2%, and 5.4% respectively, but, since 1960, the respective growth rates have averaged 4.1%, 6.3%, and 6.0% annually.

All the natural gas data are from the U. S. Bureau of Mines [9] and [12].

Table 3-1
CALIFORNIA NATURAL GAS CONSUMPTION & PRODUCTION (million cubic feet)

	Markketed Production	Received	Total Consumption	Delivered to Consumers	Residential	Commercial	Industrial	Electrical Utilities	Other
1970	649,117	1,566,146	2,156,367	2,017,393	552,544	203,669	618,647	636,257	6,246
69	677,689	1,452,623	2,078,868	1,948,269	562,127	202,946	589,750	589,531	3,915
68	714,893	1,416,580	2,078,719	1,936,146	517,636	186,688	544,292	684,315	3,015
67	681,080	1,329,287	1,945,935	1,792,221	552,122	181,392	508,755	579,952	
66	689,607	1,199,395	1,884,878	1,724,089	496,189	170,954	460,245	596,701	
65	660,384	1,162,803	1,757,292	1,562,311	489,147	163,532	419,431	492,201	
64	664,051	1,130,068	1,737,341	1,549,595	466,607	141,963	422,259	518,766	
63	646,486	964,644	1,554,126	1,371,384	416,210	125,467	399,735	429,792	
62	564,220	984,253	1,476,322	1,294,948	415,484	124,321	358,483	396,660	
61	556,241	881,483	1,405,882	1,225,335	375,603	112,774	340,408	396,550	
60	517,535	838,824	1,311,253	1,136,244	364,804	108,862	339,586	322,992	
55	538,178	507,157	1,020,395	840,244	283,691	91,029	281,860	183,664	
50	558,398	148,039	683,924	539,117	179,351	72,707	208,735	78,322	

Figure 3-1

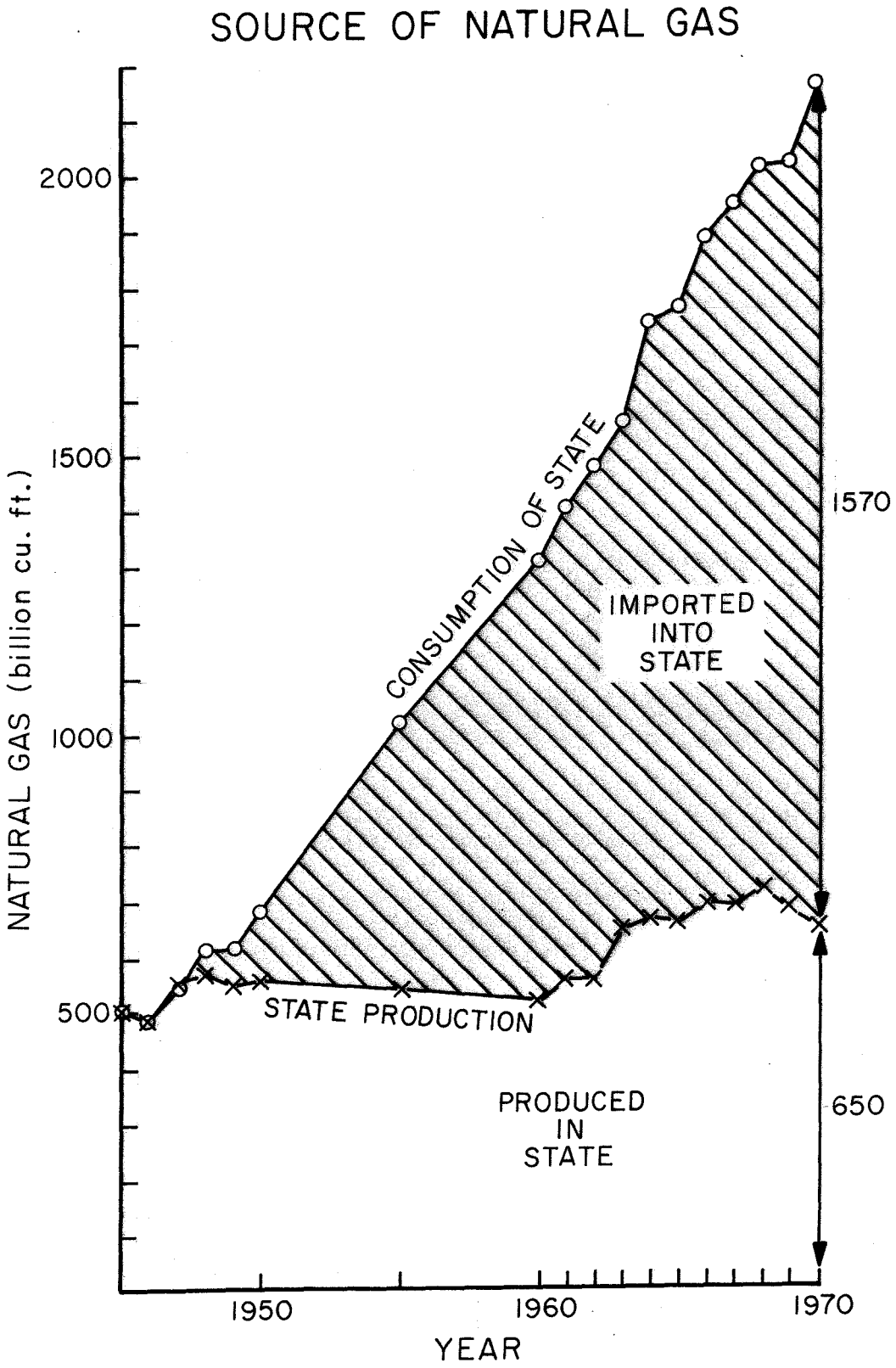
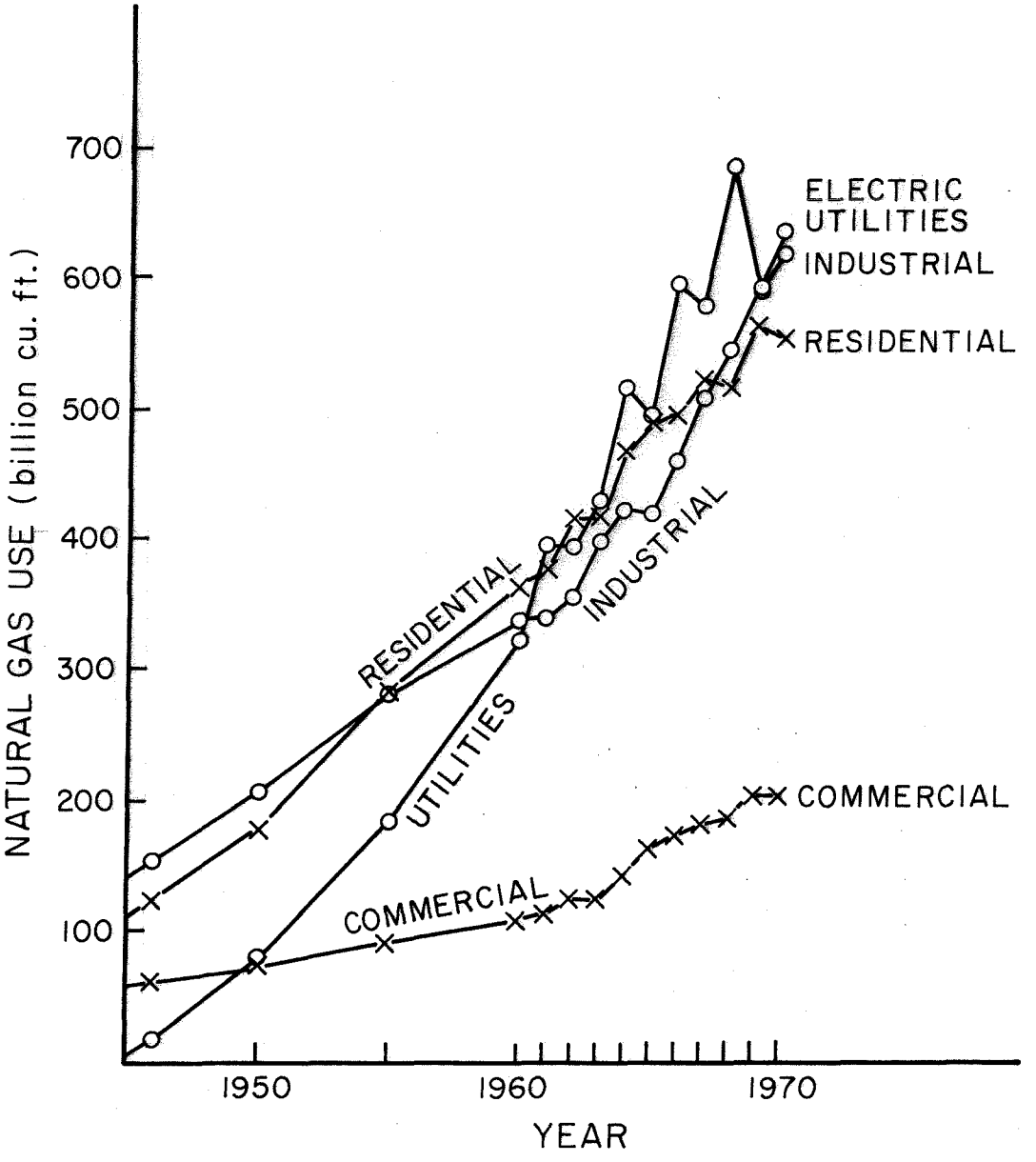

SOURCE OF NATURAL GAS
NATURAL GAS (billion cu. ft.)
2000
1500
1000
500
CONSUMPTION OF STATE
IMPORTED INTO STATE
1570
STATE PRODUCTION
PRODUCED IN STATE
650
1950
1960
1970
YEAR

Figure 3-2

CONSUMPTION OF NATURAL GAS
BY SECTOR



3.2a Electricity Generation

Ninety-nine percent of the electricity used in this state is generated by the utilities. The utilities furnish complete information to the FPC about the amount of electric power produced and the amount of fuel used to produce that power for each power plant. Table 3-2 shows the total electrical generation by the utilities and by industry for each year, and the breakdown of total electricity generation by source of energy (or prime mover) for the utilities. Tables 3-1 and 3-6 show the amounts of gas and oil used to produce that electricity. These data are available from the FPC in [6] and [7]. It is important to note that through 1970 almost all of the electricity used in California was generated in California, but in the future a greater percentage of the electrical energy used in this state will be generated outside the state. Table 3-2 includes only the electrical generation within the state.

State production of electricity has increased an average of 7.2% per year since 1950. Notice that the amount of hydroelectric power produced varies considerably from year to year depending on the amount of precipitation (Fig. 3-3). The average annual hydroelectric production is about 30% of the total, and varies from 23.4% in 1968 to 33.6% in 1969. (Note 1969, the year of List's survey, is exceptionally high for water power.) No industrial electricity is produced hydroelectrically.

The thermal efficiency of the power plants can be found by comparing the output of electricity to the calorific energy of the input fuel. For plants using gas, the overall efficiency has risen from 32% in 1960 to 35% in 1970. For plants using oil, the overall efficiency has been about 32.5% since the early 1960's. Incidentally, steam-electric plants are classified for interruptible service by the gas companies, so if the natural gas supply were reduced, more electrical generation by oil and nuclear power would be necessary.

An indication of the electrical self-sufficiency of California is shown in Fig. 3-4. The graph shows the location of projected sources of generating capacity of the state's major utilities for the next decade. In the past, the only sizeable import of electricity was from the Hoover Dam. In the last three years, power was generated at the Mojave and Four Corners coal-burning power plants for use in California and more out of state units are planned. The import capacity includes Mojave, Four Corners, Navajo, Hoover Dam, and Northwest Intertie power. By 1980, approximately 14% of California's electrical power will be from out-of-state sources. Details are available in Rolph and Lees [19].

TABLE 3-2

California E. E. Production by Prime Mover and Fuel Type

(in GWH)

	Total Utilities & Industry	UTILITIES						
		Total	Hydro.	Total Fuel	Gas	Oil	Nuclear	
				Gas & Oil & Nuclear				
1970	123,697	122,013	37,867 30.6%	84,149	68,000 55%	13,000 10%	3,475 2.8%	Percent of total
1969	120,042	118,317	40,418	77,899	63,000	11,900	2,981	
1968	116,070	114,494	27,175	87,319	74,100	11,500	1,713	
1967	109,996	108,532	35,277	73,255	61,600	11,000	623	
1966	103,229	101,964	26,236	75,728	63,500	12,100	163	
1965	94,189	93,050	30,523	62,527	52,000	10,300	271	
1964	88,385	87,202	22,098	65,104	54,100	10,700	365	
1963	79,989	78,870	25,334	53,536	44,500	8,800	194	
1962	74,729	73,626	22,834	50,792	40,600	10,200	7	
1961	70,506	69,444	15,368	54,076	39,600	14,500	5	
1960	64,899	63,834	17,445	46,390	31,600	13,500	-	
1955	43,811	42,512	14,555	27,957	17,400	17,500	-	
1950	28,466	24,836	14,809	10,027	5,800	4,200	-	

Figure 3-3

CALIFORNIA: PRODUCTION OF ELECTRICITY BY FUEL TYPE

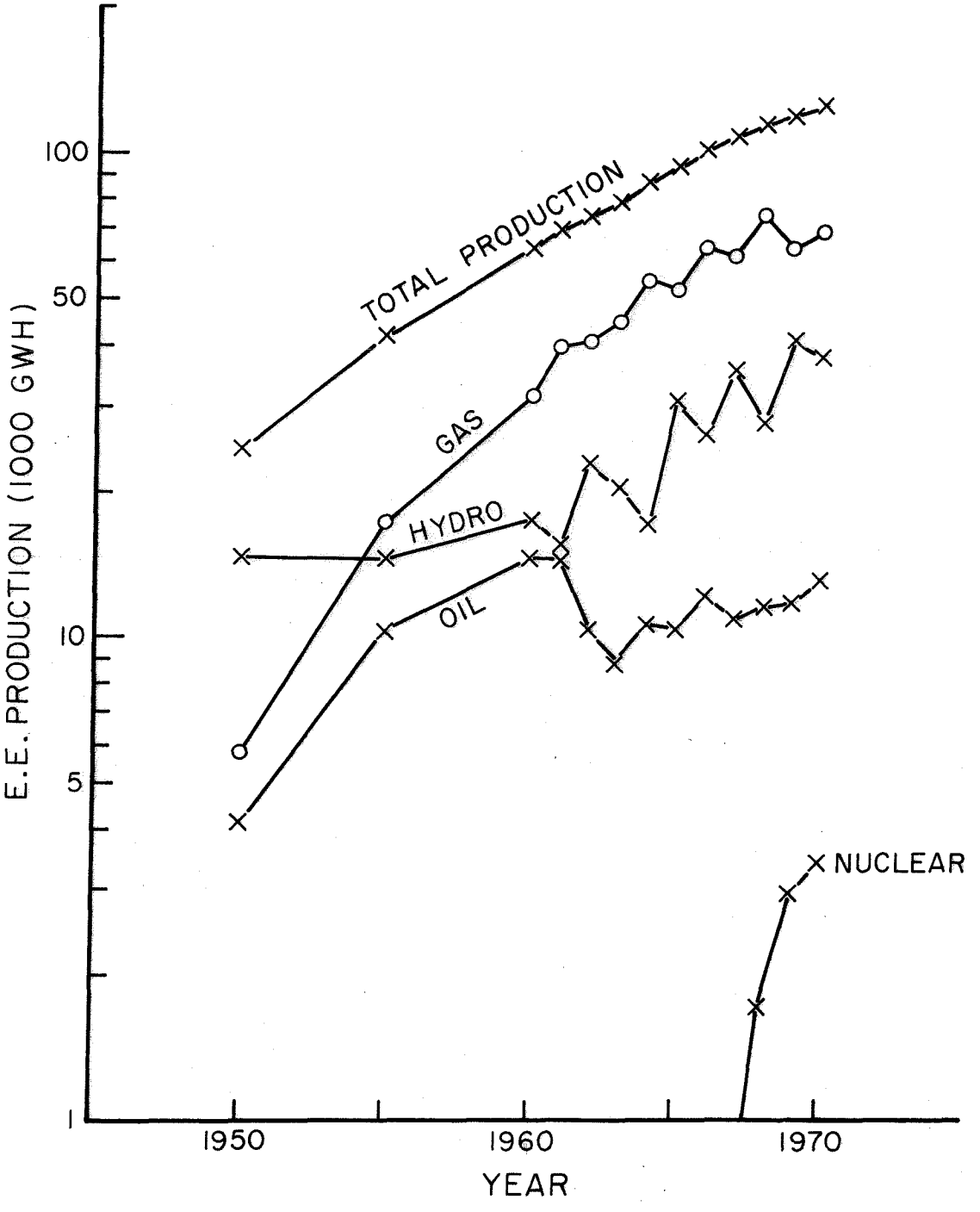
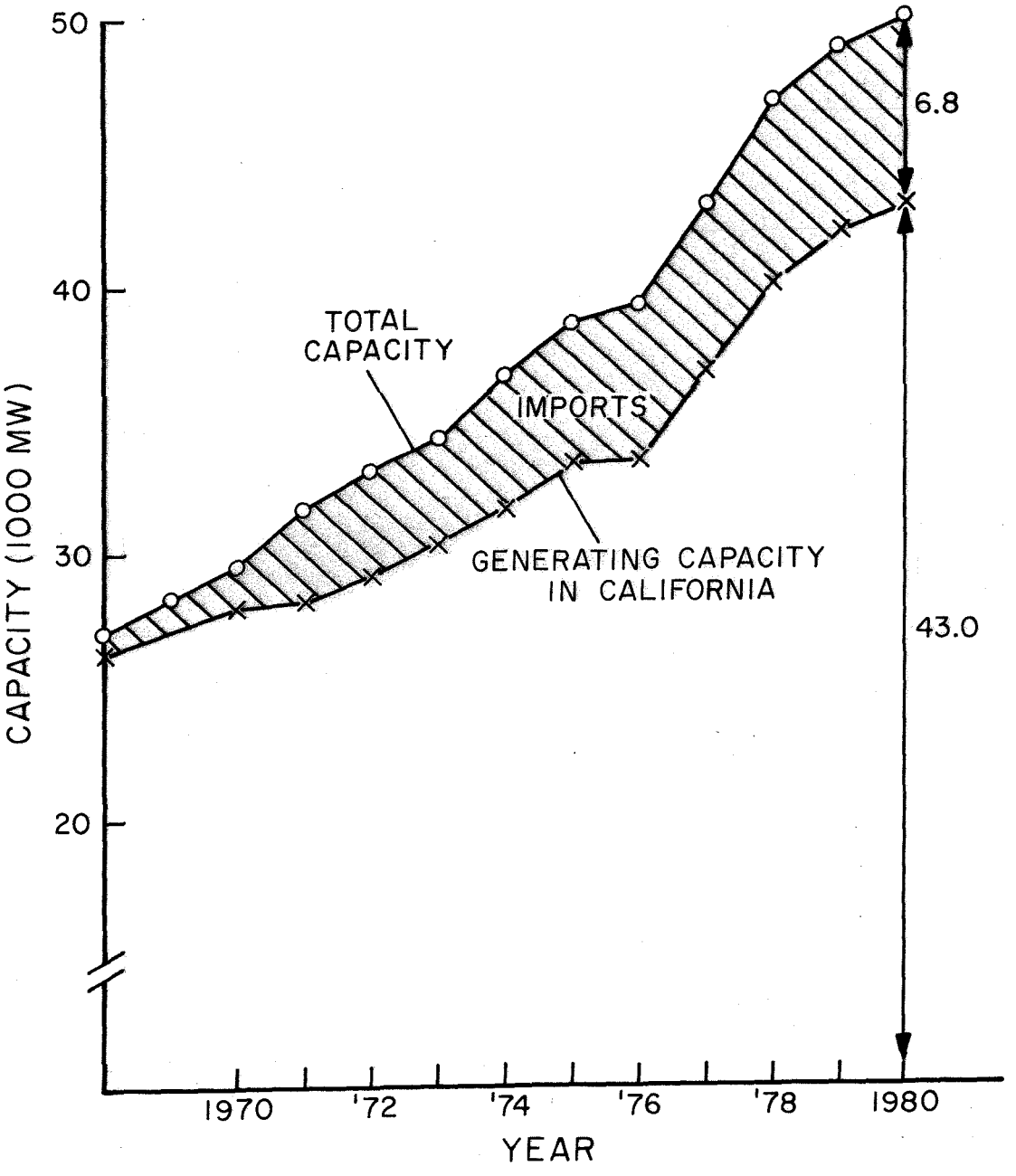


Figure 3-4

PROJECTED ELECTRICAL GENERATION CAPACITY FOR CALIFORNIA



3.2b Electricity Sales

Electricity sales in the state have risen at an average of 8% per year for twenty years (Table 3-3, Fig. 3-5), with residential, commercial, and industrial each having one-third the market. In the last ten years these three markets have all grown at the same rate. The FPC ([1] and [6]) breaks down commercial and industrial into separate categories in the years the sales were available (my estimates are in parentheses). The state of California [2] has this breakdown before 1961. The columns titled Sales are FPC figures; the columns titled Use are state figures.

Note the difference between commercial and industrial use and sales in 1960 and 1961. Evidently, the FPC and the state disagree on definitions of categories. The deviations from straight lines in Fig. 3-5 are due to this difficulty as much as any real historical cause.

Comparison of electrical production and electricity sales give an indication of the efficiency of transmission. There is some net import of electricity into California, probably less than 5% of the electricity produced in the state, which should be added to the production data given in Table 3-2 for this calculation. In 1969, 118,317 GWH of electricity were produced for use in California, while 111,392 GWH were sold. Thus, there is about a 7.7%. [1]

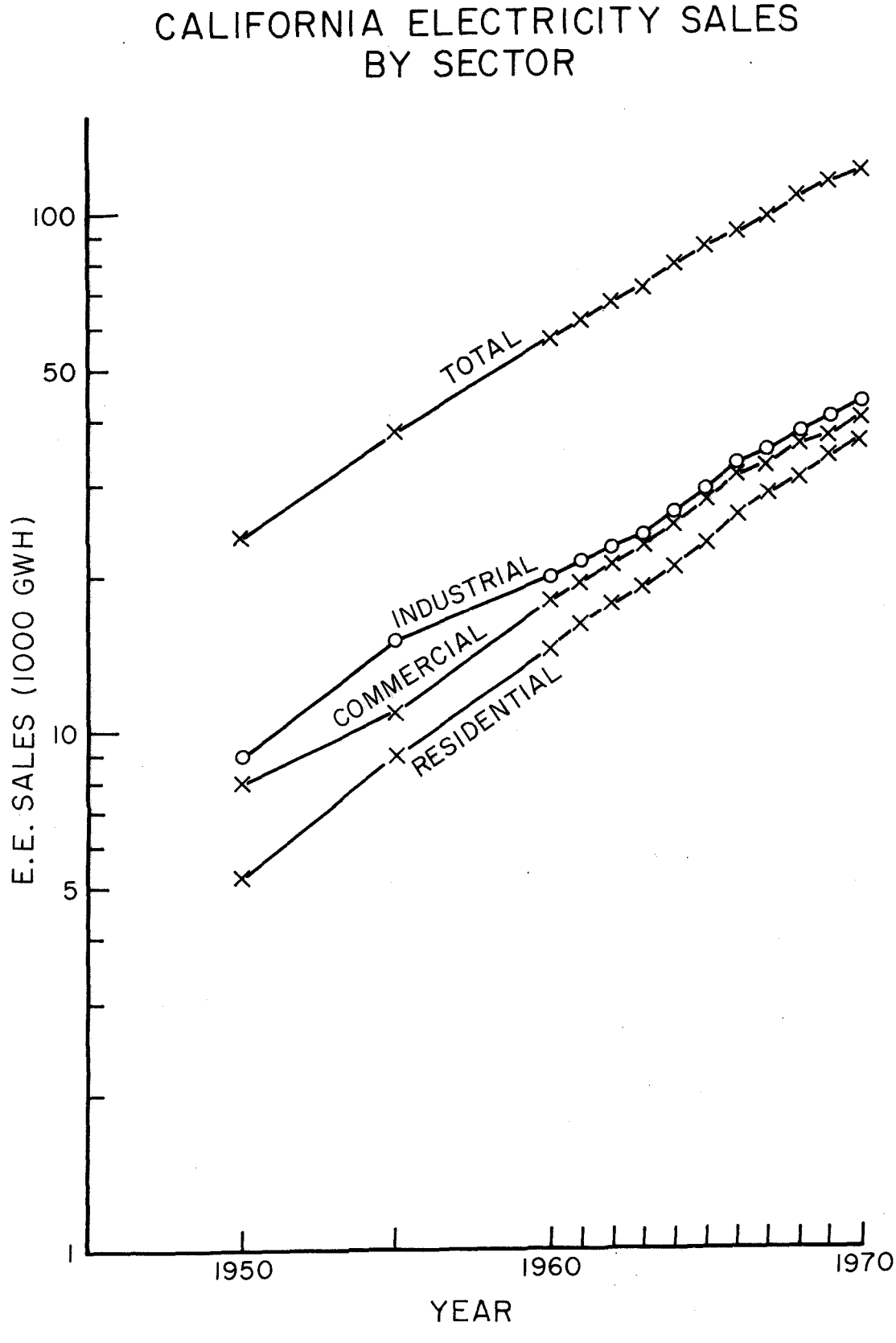
energy loss in transmission. The corresponding calculation for 1970 shows only a 4% transmission loss -- reflecting the increased import of power. Hence, electricity consumed here is about 5 - 10% greater than the amount sold.

Table 3-3
CALIFORNIA E.E. USE AND SALES BY CLASS OF SERVICE (in GWH)

	Total		Residential		Commercial & Industrial			
	Use	Sales	Use	Sales	Use	Total Sales	Commercial	Industrial
1970		117,642		35,774		81,439	39,340	42,099
69		111,392		33,709		76,335	36,651	39,684
68	108,274	104,561	29,490	30,544	72,163	72,788	35,604	37,184
67	100,454	96,976	27,755	28,713	66,270	67,154	32,691	34,463
66	94,756	90,893	25,417	25,993	63,711	63,822	31,671	32,151
65	85,403	(82,000)	22,994	(23,000)	56,838	(57,000)	(28,000)	(29,000)
64	79,723	(77,600)	20,688	(21,000)	51,624	(51,600)	(25,000)	(26,600)
63	71,736	(70,000)	18,840	(19,000)	46,640	(46,600)	(23,000)	(23,600)
62	66,758	(66,000)	17,253	(17,400)	43,650	(43,600)	(21,000)	(22,600)
61	62,691	62,350	15,773	16,253	41,321	40,978	19,536	21,442
60	57,765		14,390		38,326			
//								
55	37,719		8,890		25,845			
50	23,871		5,160		16,925			

	Use		
	Commercial	Irrigation	Industrial
1960	8,370	5,267	24,689
55	5,920	4,437	15,488
50	4,096	3,273	9,556

Figure 3-5


CALIFORNIA ELECTRICITY SALES
BY SECTOR
E.E. SALES (1000 GWH)
100
50
10
5
1
TOTAL
INDUSTRIAL
COMMERCIAL
RESIDENTIAL
1950
1960
1970
YEAR

3.3 Gasoline and LPG

Gross consumption of gasoline has increased at an average 4.3% annually for the past twenty years (Table 3-4). About 95% is used on public streets and highways. The rest is used in aviation, agriculture, lumbering, quarrying, boating and contracting. Highway use is given in Table 3-5.

The LPG data have been divided into two parts according to whether or not the LPG was actually burned. The column titled "Sales of LPG and ethane" is the amount used for combustion. This is the figure List [18] gives for LPG use. However, a large part of LPG use is for chemical feedstock for gasoline production, secondary recovery of petroleum, and chemicals and synthetic rubber. This estimated amount added to "Sales of LPG" is indicated under "LPG - All Uses."

All data are from the Bureau of Mines [9], [11].

TABLE 3-4

California Gasoline and LPG Use

(million gallons)

	GASOLINE GROSS CONSUMPTION	LPG (ALL USES)	SALES OF LPG & ETHANE
1970	9250	790	470
1969	8860	690	387
1968	8440	610	328
1967	7980	580	310
1966	7770	520	259
1965	7480	550	313
1964	7280	570	317
1963	6840	560	333
1962	6510	480	309
1961	6280	470	271
1960	6010	450	272
1955	5620		
1950	3855		

3.4 Highway Fuel Consumption

Table 3-5 shows motorists' use of gasoline and special fuels on public roads. (A highway means any public road here.) The data are from [2], "Gallons Taxed on Roads," so they do not include tax free uses such as for heavy construction machinery. The special fuels column includes diesel oil and a small amount of LPG. From 1960 to 1970, highway consumption of gasoline increased an average of 5.1% annually and special fuels usage increased an average of 7.3% annually. The average increase in total motor fuel consumption was 5.2% per year in this period.

In 1970, highway usage accounted for 95% of the state's gross gasoline consumption and 86% of the diesel oil usage shown in Table 3-6.

TABLE 3-5

Highway Fuel Consumption
(million gallons)

	GASOLINE	SPECIAL FUELS	TOTAL MOTOR FUEL
1970	8932	599	9531
1969	8537	578	9115
1968	8103	494	8597
1967	7602	454	8056
1966	7367	451	7818
1965	6977	418	7395
1964	6685	319	7004
1963	6274	360	6634
1962	5915	338	6253
1961	5615	321	5936
1960	5386	305	5691
1955	4191	215	4406
1950	3096	117	3213

3.5 Fuel Oil

Total fuel oil use has remained fairly constant over the last decade while the proportion of distillate has risen from 25% in 1960 to a 38% share of the market in 1970. (See Table 3-6 and Fig. 3-6). Total use here includes vessels and trains that were fueled in California and used much of that fuel in other places. List's more detailed analysis [18] estimates 10% of the vessel bunkering fuel, and 20% of the railroad fuel was burned in the state in 1969. The portion of fuel used by the military in the state is unknown.

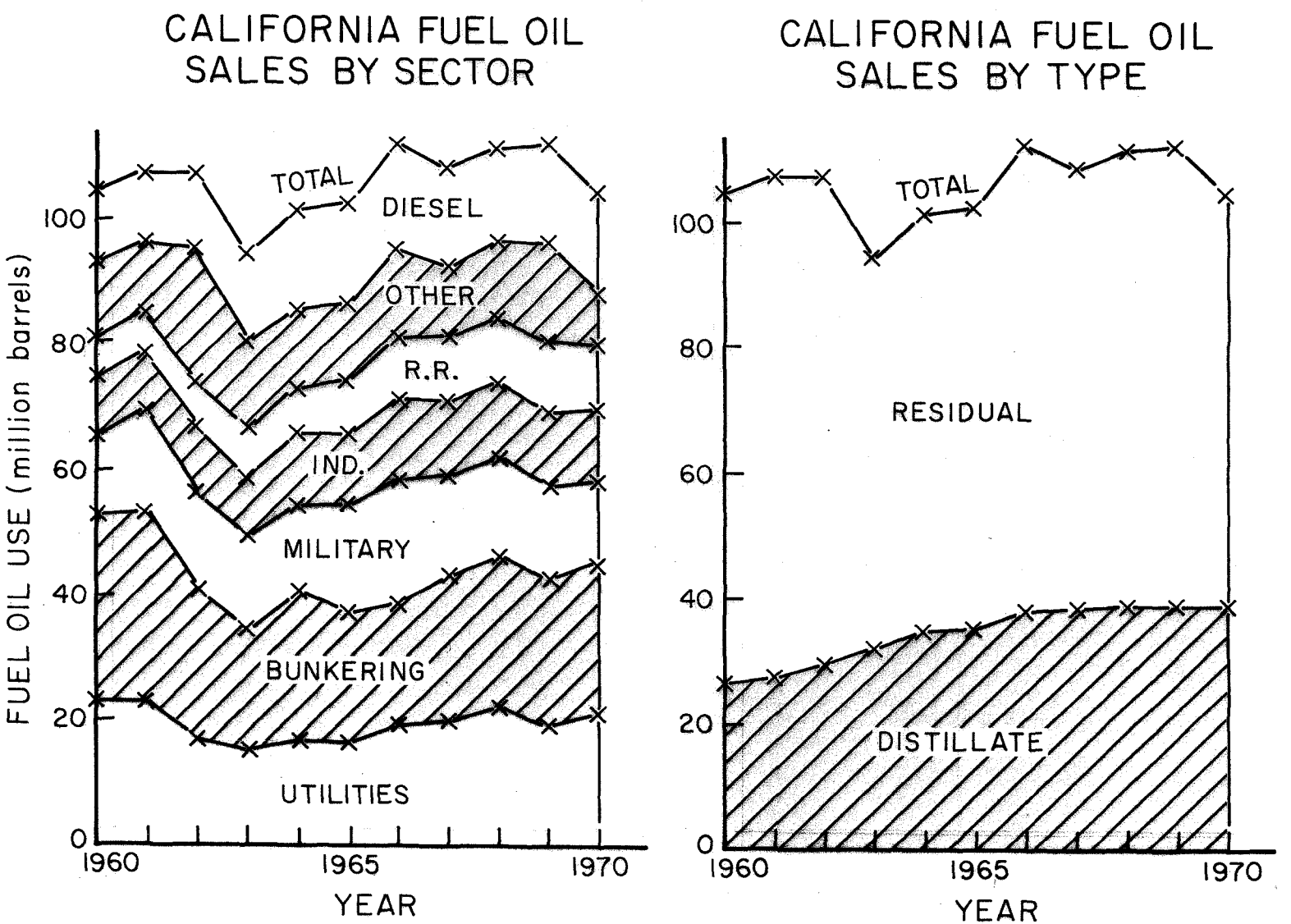
Railroads and diesel engines use the lighter and less polluting distillate oil almost entirely. Electric utilities, vessels, and oil companies use the more viscous and less volatile residual oils. The percentage of distillate oil used in each category is shown for 1960 and 1970. Also, the percentage used by each category as a share of the total fuel oil market is shown for those two years. Electric utilities and vessel bunkering have the largest shares of the market. (A bunker is the fuel storage room of a ship.)

All the data are from the U. S. Bureau of Mines [10].

Table 3-6
CALIFORNIA FUEL OIL USE (1000 Barrels)

	Total		Oil Company								
	Distillate	Residual	Industrial (not Oil Co.)		Railroads	Vessel Bunkering	Military	Heating	Kerosine	Diesel	Electric Utilities
% Distillate	100%	0	44%	8%	99%	10%	23%	38%	—	100%	0.6%
1970	39,188	65,505	11,866	7,487	10,111	23,934	13,255	3,758	1,004	16,392	21,695
% of Total Use	38%	64%	11%	7%	10%	23%	13%	3%	1%	16%	21%
69	39,112	73,638	11,826	7,064	10,607	23,289	15,181	3,512	808	16,341	19,790
68	38,519	73,420	12,456	9,102	10,273	24,043	16,174	3,538	600	15,441	22,350
67	38,767	70,407	11,721	8,940	9,910	23,320	16,736	3,224	795	(NA)	20,385
66	38,335	75,104	13,124	9,560	9,681	19,479	20,111	3,384	861	17,286	19,390
65	35,672	67,614	11,368	8,779	8,338	20,787	17,471	3,394	818	16,222	16,692
64	34,991	66,927	11,751	9,467	7,827	23,868	13,800	3,797	951	15,922	17,230
63	32,256	62,842	9,337	8,268	8,002	19,443	14,804	5,131	859	14,381	15,739
62	29,685	68,949	10,473	6,544	7,014	23,618	16,037	4,657	994	11,891	17,156
61	27,410	81,587	9,801	5,273	5,932	30,219	15,913	6,890	1,061	11,663	23,287
60	26,697	78,774	9,373	6,504	5,960	29,287	12,442	7,793	1,015	(NA)	(23,515)
% of Total Use	25%	75%	9%	6%	6%	29%	12%	7%	1%	11%	23%
%Distillate	100%	0	32%	6%	85%	8%	20%	43%	—	100%	10%

Figure 3-6


CALIFORNIA FUEL OIL SALES BY SECTOR
FUEL OIL USE (million barrels)
TOTAL
DIESEL
OTHER
R.R.
IND.
MILITARY
BUNKERING
UTILITIES
0
20
40
60
80
100
1960
1965
1970
YEAR
CALIFORNIA FUEL OIL SALES BY TYPE
TOTAL
RESIDUAL
DISTILLATE
0
20
40
60
80
100
1960
1965
1970
YEAR

4.1 Natural Gas Sales - South Coast

Annual total gas sales in the South Coast increased sharply between 1967 and 1968 and have been nearly constant since that time. More than 95% of the gas sold in this air basin is sold by Pacific Lighting Corporation through its subsidiary, the Southern California Gas Company. Their data for gas sold in this air basin go back only to 1967, which was the first year they were required to tabulate their sales for the California Air Resources Board. The Long Beach Gas Department sells the rest of the gas.

While the breakdown of users into residential, commercial, and industrial (other than refineries and power plants) was not available for this air basin, the system-wide breakdown for Pacific Lighting Corporation was available. Since this air basin provides about 85% of that company's sales, the proportionate system-wide breakdown was felt to be a fair approximation for the breakdown in this air basin. The data for gas used in steam-electric plants are from the FPC [21]. The sales to power plants given by the companies are unaccountably about 8% less than these figures, but we feel the FPC figures are more accurate. Total sales and total interruptible sales have been increased to take this discrepancy into account. References are [16], [17], [21], [22].

Table 4-1
NATURAL GAS SALES IN SOUTH COAST (billion cubic feet)

	Estimates							
	Total Sales	Residential	Commercial	Other Industrial	Steam Electric Plants	Oil Refineries	Total Firm	Total Interruptible
1971	875	(307)	(114)	(138)	282	34	421	454
70	909	(279)	(104)	(133)	366	27	383	526
69	903	(284)	(104)	(133)	355	27	388	515
68	908	(259)	(95)	(123)	400	31	354	554
67	838	(260)	(84)	(120)	354	20	344	494

4.2a Electricity Sales - South Coast

South Coast electricity sales are given in Table 4-2 (see also Fig. 4-1). Total sales have increased an average of 7.9% annually with industrial sales increasing at a slightly smaller 6.5% average, and residential and commercial sales averaging a 9.1% increase annually. In 1971, the portion of electricity sold to each market was: Industrial 33%; Commercial 31%; Residential 27%; Public Authorities 9%.

The table was computed by taking 96% of SCE's sales (or SCE plus California Electric Company before 1963) and adding the sales of the publicly owned electric utilities in the basin. The percentage of 96 was obtained from the U. S. census figures in the SCE service territory which showed that both in 1960 and 1970 approximately 96% of service territory population was in the Basin. It was assumed the electricity sales were in proportion to the population. The agriculture figures are a guess - they are 1/2 SCE's total agricultural use. The other figures are probably accurate to within 5%. References are [13], [14], [15], [7], and [8].

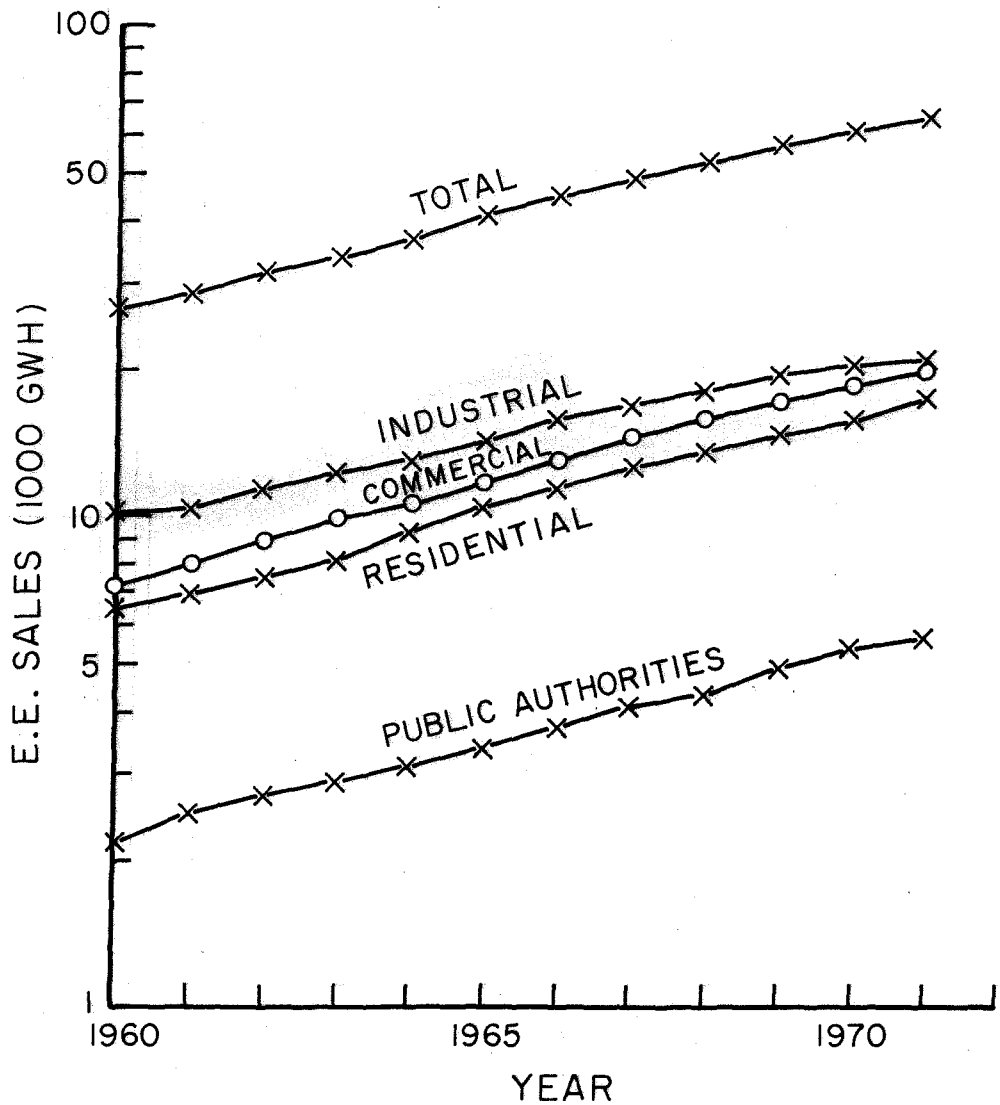
TABLE 4-2

South Coast Electricity Sales
(1000 GWH)

	Total	Res.	Comm.	Ind.	Public Authorities	Agri.
1971	64.2	17.3	19.8	20.9	5.6	(0.6)
1970	60.8	15.8	18.4	20.6	5.4	(.6)
1969	56.8	14.9	17.1	19.4	4.9	(.5)
1968	52.6	13.6	15.9	18.2	4.3	(.6)
1967	48.8	12.7	14.5	17.0	4.1	(.5)
1966	44.8	11.5	13.0	16.0	3.7	(.6)
1965	40.6	10.6	11.8	14.3	3.4	(.5)
1964	36.7	9.3	10.6	13.1	3.1	(.6)
1963	33.8	8.2	9.9	12.3	2.9	(.5)
1962	31.88	7.6	9.0	11.5	2.7	(.6)
1961	28.8	7.0	8.0	10.6	2.5	(.6)
1960	27.0	6.5	7.3	10.2	2.2	(.6)

Figure 4-1

SOUTH COAST ELECTRICITY
SALES BY SECTOR

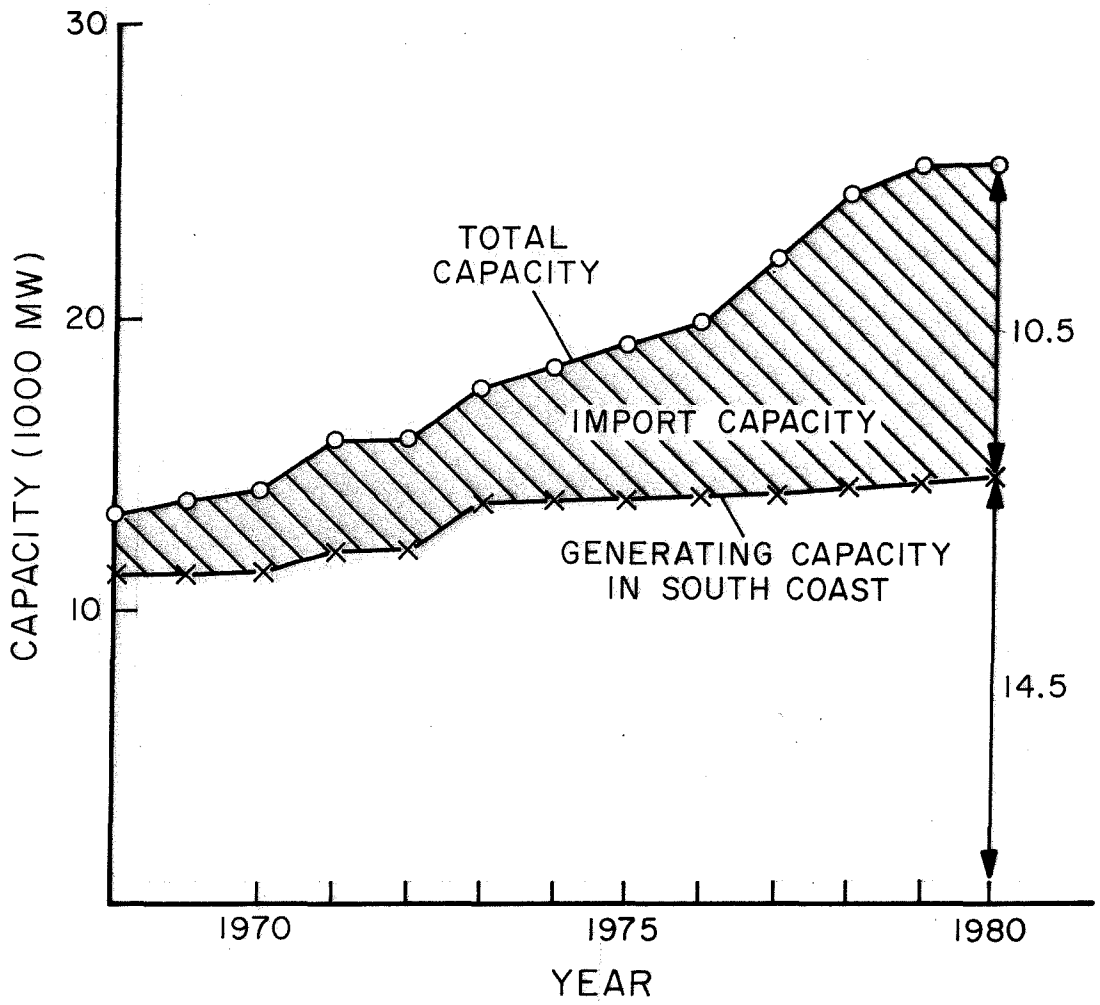


4.2b Electricity Imports - South Coast

By 1980, the South Coast will be very dependent on imported electrical power generated outside the Basin -- approximately 41% of the capacity of the system will be imported (see Fig. 4-2). In 1968, only 15% of the capacity was imported. The large power plants that are part of the SCE-LADWP electrical network that are not in the South Coast basin are San Onofre, Mojave, Four Corners, Navajo, and Frye Mountain. Imports as large as 41% suggest the South Coast is very fortunate in being able to give other regions the pollution problems associated with its own prosperity. The sources of information on the location of power plants are [5], [19], [20].

Figure 4-2

PROJECTED ELECTRICAL CAPACITY FOR SOUTH COAST AIR BASIN



4.3 Highway Fuel Consumption - South Coast

The highway fuel consumption of the South Coast is found assuming all vehicles in the state use the same amount of fuel. The estimated number of vehicle registrations in the South Coast is shown in the appendix (Table A-3). Then, gasoline usage is computed from the percentage of California passenger vehicle registrations in the Basin. Special fuels usage is computed from commercial vehicle registrations in the same manner. Note the low percentage of special fuels used in the Basin as compared with the percentage of gasoline used in the Basin. This does not seem to reflect the economic activity in the South Coast, and therefore these figures are somewhat suspect.

Table 4-3
HIGHWAY FUEL CONSUMPTION – SOUTH COAST (million gallons)

	Gasoline		Special Fuels		Total Motor Fuels	
		% of State	Diesel	% of State		% of State
1969	4330	50.7%	228	39.4%	4558	50.3%
68	4130	51.0%				
67	3880	51.0%				
66	3760	51.0%				
65	3550	50.9%	167	39.9%	3717	50.3%
64	(3400)	(50.7%)				
63	(3200)	(50.7%)				
62	(3000)	(50.7%)				
61	2840	50.6%	128	39.7%	2968	50.1%
55	2150	51.4%				
50	1510	48.9%				

5. Per Capita Energy Use

We can separate the growth of energy use into two parts - the part due to increased per capita usage and the part due to population increase (ignoring any cause-and-effect relations between population growth and per capita consumption). Table 5-1 and Fig. 5-1 show the average per capita usage of the four most important forms of energy as they reach the consumer, and an estimate of the total energy use per person in the state. Natural gas is the Total Consumption of Table 3-1 minus the use for utilities; Fuel Oil is Total Distillate plus Total Residual minus the use for utilities of Table 3-6; Total Motor Fuel is from Table 3-5; Energy of fuel used for production of electricity is the calorific energy of the gas and oil used by utilities plus the amount of electrical energy produced by hydroelectric and nuclear power. The estimated grand total is computed by assuming these four forms of energy provide 90% of all the energy used as suggested in List's report [18].

Sadly we note the fastest growing form of energy, electricity, is sometimes terribly inefficient. Electric energy sales are about 42% of the energy needed to produce that energy. This production becomes more efficient when hydroelectric power is more available and less efficient otherwise - this is the cause

of the oscillations in the electricity production curve. However, both natural gas and motor fuel are still more important sources of energy.

The estimated total per capita usage is increasing at an average of 1.7% annually with natural gas excluding utilities averaging 1.9%, motor fuel averaging 2.8%, and electricity sales averaging 4.7%. Per capita fuel oil usage is decreasing.

Comparing the per capita usage of California and the South Coast (see Table 5-2) we see that recently the gas sales per capita have not increased in the Basin while the electricity sales have risen faster than the state average. This table also shows that not only is more motor fuel being used per person (1.3 gallons per day in 1970), but more gasoline is being used per passenger vehicle (2.4 gallons per day). More people are buying more cars per person and driving them further per car every year.

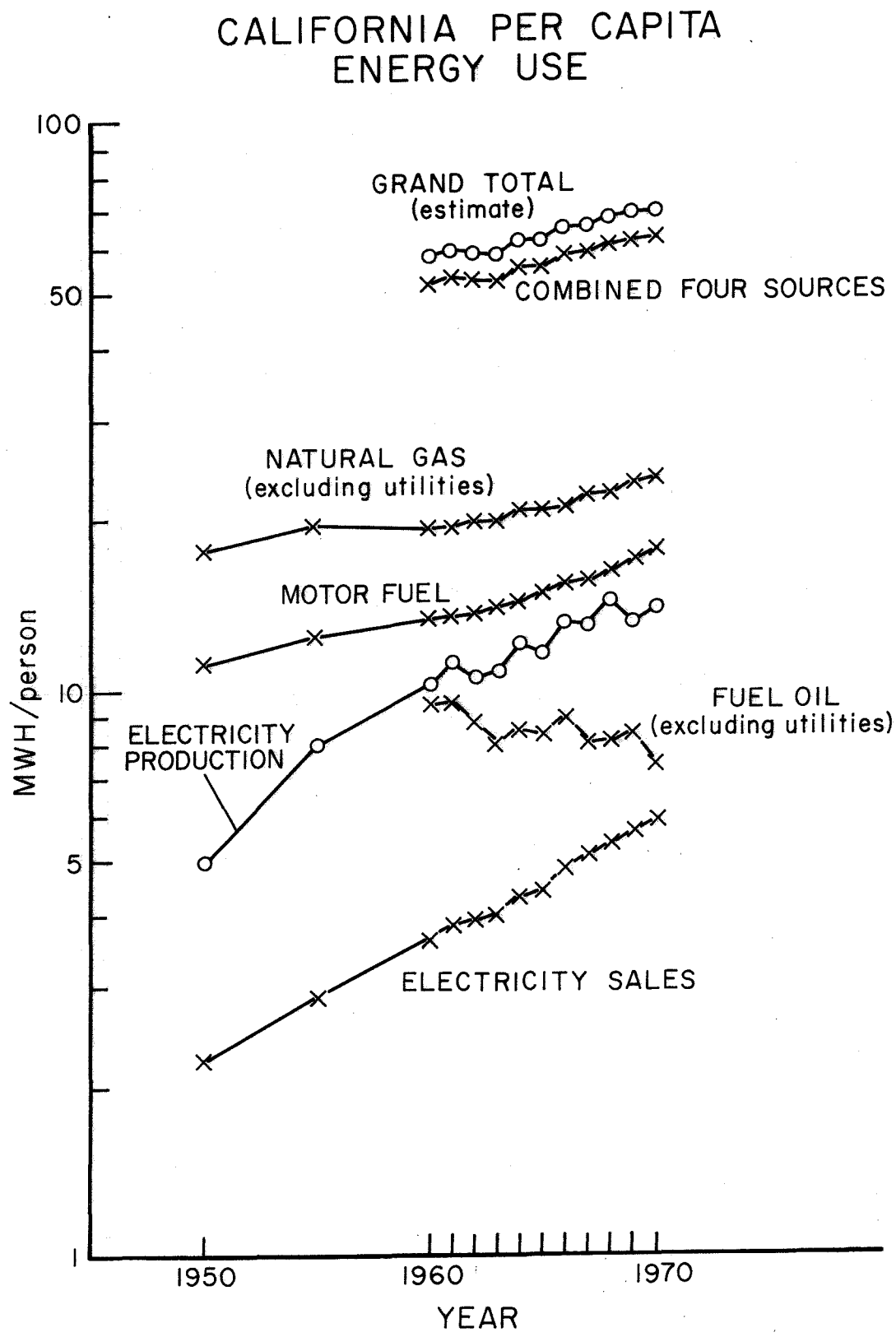
Table 5-1
PER CAPITA USAGE – CALIFORNIA (MWH / person)

	Natural Gas (excluding use for electricity)	Total Motor Fuel	E.E. Sales	Energy of Fuel used in production of E.E.	Fuel Oil (excluding use for E.E.)	Total of Gas, E.E., Motor fuel, Oil (represents approximately 90% of all power used)	Estimated Grand Total
1970	23.4	17.6	5.90	13.9	7.4	62.3	69.2
69	23.2	17.0	5.64	13.2	8.4	61.8	68.7
68	22.1	16.2	5.37	14.4	8.2	60.9	67.6
67	22.0	15.5	5.06	13.1	8.2	58.8	65.3
66	21.1	15.3	4.84	13.1	8.9	58.4	64.9
65	20.9	14.8	4.45	11.6	8.4	55.7	61.8
64	20.9	14.4	4.32	12.0	8.5	55.8	61.9
63	19.8	14.0	4.01	10.7	8.1	52.6	58.5
62	19.8	13.7	3.93	10.5	8.8	52.8	58.7
61	19.3	13.5	3.84	11.1	9.5	53.4	59.3
60	19.3	13.3	3.67	10.2	9.4	52.2	58.1
55	19.7	12.5	2.90	8.0			
50	17.8	11.2	2.25	5.0			

Table 5-2
PER CAPITA USAGE – CALIFORNIA & SOUTH COAST

	California				South Coast	
	Total Consumption Natural Gas MCF/Capita	Total Motor Fuel gals/person	Gasoline on Highway gals/passenger vehicle	E.E. Sales per Capita KWH/person	Natural Gas Sales MCF/person	E.E. Sales KWH/person
1971					88	6480
70	108	478	(NA)	5900	93	6200
69	105	461	868	5640	93	5840
68	106.5	441	860	5370	95	5510
67	101.5	420	854	5060	89	5190
66	100	416	838	4840		4880
65	95	401	811	4450		4490
64	97	390	(NA)	4320		4170
63	89	380	(NA)	4010		3980
62	88	373	(NA)	3930		3910
61	87	366	799	3840		3660
60	83.5	362	795	3670		3560
55	(78)	(339)	780	2900		
50	65	304	755	2250		

Figure 5-1


CALIFORNIA PER CAPITA
ENERGY USE
100
50
10
5
1
MWH/person
GRAND TOTAL
(estimate)
COMBINED FOUR SOURCES
NATURAL GAS
(excluding utilities)
MOTOR FUEL
FUEL OIL
(excluding utilities)
ELECTRICITY
PRODUCTION
ELECTRICITY SALES
1950
1960
1970
YEAR

6. Cost of Energy to the Consumer

What is the direct cost of energy to the consumer? We can answer this in terms of a gas bill, electric bill, and the annual cost of gasoline. In uninflated 1958 dollars, Table 6-1 shows the residential price per KWH of electricity has increased for SCE customers, the average cost per MCF of gas has dropped for firm customers of Southern California Gas Company, and the wholesale gasoline price has dropped in the nation as a whole.

But during this period the average real income of Californians has increased an average of 2.35% annually, which dominates the increased per capita use (and for electricity, the increased cost) so that the total cost, as a percent of income, has decreased in the last decade. A table of California Average Income and the U.S. Implicit Price Deflator is included in the appendix.

TABLE 6-1

Cost Data

Real Cost per Unit Fuel

in constant 1958 dollars.

SCE: Residential ¢/KWH:	1970	2.88¢
	1965	2.22¢
	1960	1.80¢
Southern California Gas Company: Firm ¢/MCF:	1970	71.3 ¢
	1965	83.4 ¢
	1961	96.0 ¢
Wholesale Gasoline ¢/gal. (U. S.)	1969	13.3 ¢
	1965	13.9 ¢
	1960	15.6 ¢

Percent of Average Annual Income Spent on Energy

		Percent of Income	Average Annual Bill
Electric Bill (SCE)	1970	2.85	$127.40
	1965	2.89	94.00
	1960	2.98	80.69
Gas Bill (Pacific Lighting Company)	1970	2.76	$123.54
	1965	3.40	110.29
	1961	3.74	104.24
Gasoline (including taxes) (based on average per capita use of gasoline)	1969	3.36	
	1965	3.54	
	1960	3.94	

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[22] Long Beach Gas Department, Personal Communication.

Appendix

TABLE A-1

Calorific Values of Fuels

1 million cu. ft. natural gas	=	308 MWH
1 million gallons gasoline	=	36,700 MWH
1 million gallons LPG	=	27,000 MWH
1 million gallons diesel	=	40,600 MWH
1000 bbls. residual oil	=	1841 MWH
1000 bbls. distillate oil	=	1705 MWH

1 bbl.	=	42 gallons
1 GWH	=	1,000,000 KWH
1 GWH	=	1,000 MWH

TABLE A-2

	CALIFORNIA AVERAGE INCOME *	U. S. IMPLICIT PRICE DEFLATOR
1970	$4469	134.9
1969	4232	128.1
1968	3993	122.3
1967	3697	117.6
1966	3457	113.9
1965	3241	110.9
1964	3112	108.8
1963	2974	107.1
1962	2881	105.5
1961	2794	104.1
1960	2708	103.3
		100.0 in 1958 by definition
1955	2313	90.9
1950	1852	80.2

* per capita

TABLE A-3

MOTOR VEHICLE REGISTRATIONS (in thousands)

	CALIFORNIA			SOUTH COAST		
	Passenger	Commercial	Passenger vehicles per person	Passenger	Commercial	Passenger vehicles per person
1969	9847	1767	.50	4985	696	.51
1968	9419			4800		
1967	8895			4539		
1966	8785			4483		
1965	8597	1420	.47	4373	567	.48
1961	7030	1080	.43	3556	428	.45
1955	5372	784		2754		
1950	4101	506	.39	2001		.41

The most important fact about this table is that the number of commercial registrations in the South Coast may be misleading. We see that a smaller proportion of the vehicles in the South Coast are commercial vehicles than in the state as a whole; in 1969, 12.3% in the South Coast vs. 15.2% in the state as a whole. This could reflect more pick-up trucks being used as transportation in rural areas, or some companies registering vehicles outside the basin for tax reasons. In either case, the smaller proportion of commercial registrations does not seem to reflect the economic activity in the South Coast.

The table is the sum of both fee-paid and fee-exempt registrations as found in [3]. This reference gives the county registrations, and these are divided in proportion to the population in or out of the Basin in order to obtain the South Coast data.